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(19)(CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Injection Molding Method and Apparatus for Preparing Dental Prosthesis and Medical Devices

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(57) 15 Claims

ABSTRACT OF THE DISCLOSURE

The disclosure describes an injection molding station for a diaphragm cartridge for use in preparing dental prosthesis and medical devices in general. The cartridge and corresponding machine allow for complete injection of thermoplastic resin. The cartridge is a predominantly cylindrical flat cartridge with a conical opening. Plastic resin is ejected from the opening in the cartridge when a heated plunger is pushed on the bottom of the cartridge. During the injection of the resin into the flask, the bottom of the cartridge is deformed to eliminate the bursting of the cartridge. The cartridge is utilized in a station in which the cartridge is positioned in a tubular heating chamber with heating elements located on the plunger and the circumference of the cartridge. The cartridge is inserted into a compression plate which supports the flask and controls the deformation of the cartridge. The resin flows through the opening into a reversible flask made of primarily two parts, which are automatically clamped together without the use of clamping devices. The cartridge has more thermoplastic resin than is required to fill the flask, to eliminate the possibility of thermal shrinkage and producing a less than optimum prosthesis.

TITLE OF THE INVENTION

Injection molding method and apparatus for preparing dental prosthesis and medical devices.

FIELD OF THE INVENTION

The present invention relates to a transfer molding station and diaphragm cartridge for use in preparing dental prosthesis and medical devices in general. In addition, the invention includes a method for preparing the prosthesis.

BACKGROUND OF THE INVENTION

Conventional denture manufacturing devices and methods suffer from inadequacies and drawbacks. Conventional materials are made by manually mixing a powder of polymethylmethacrylate with liquified methylmethacrylate monomer in order to obtain a plastic (dough) material. These materials can be processed using compression and/or injection molding systems. Various methods can be used to cure the material: self-curing, heat-curing in hot water, light-curing and microwave curing.

The disadvantages of these systems are due to, among other things, curing shrinkage of the molding material which occurs during the molding process, the presence of residual monomer which is toxic, a high

porosity and a high water absorption leading to poor dimensional accuracy.

Acrylic dentures tend to shrink during the curing process, and, as a result, conventional molding machines overcharge or overpack the mold to compensate. The pressure must be maintained during the curing phase and this overcharging is usually inadequate and is difficult to control.

Some denture manufacturing devices are based on the injection of a thermoplastic material. These devices are actionned using an air-injection mechanism and injection pressures are relatively low. So, these methods are limited to non-viscous polymers having poor mechanical properties such as thermoplastic acrylics.

Injection molding equipments suffer from the drawback of inadequate spruing of the thermoplastic material into the mold. If the sprues do not enter the mold cavity at the proper location, strains in the denture result which may also tend to lift the dentures away from the mold and also to give a poor dimensional accuracy.

If the flask halves are improperly closed or if the flask cannot resist to the injection force, a change in the position of the teeth relative to one another may

occur, which can cause an adverse effect on the articulation of teeth in the patient's mouth and alter the patient's jaw position, increasing discomfort.

Furthermore, conventional thermoplastic injection devices are complicated and require significant operator adjustment and time, particularly for the cleaning of the machine.

OBJECTS OF THE INVENTION

According to the foregoing, it is an object of the present invention to provide an apparatus and method for producing dentures in which a cartridge containing thermoplastic resin is employed, wherein the cartridge has a unique design to eliminate the cleaning of the machine and facilitate the flow of resins in the cavity.

Another object of the present invention is to provide an injection molding apparatus with a tubular heating chamber to melt uniformly the thermoplastic resin included in the cartridge.

Another object of the present invention is to provide an apparatus and method in which the flask and the injection apparatus are self-aligning and auto-clamping.

Another object of the present invention is to provide an injection molding apparatus with a tubular heating chamber which can be closed safely and resist to the force generated by the mechanical power unit and supply the clamping force to keep the flask closed.

Another object of the present invention is to provide a flask and a method which can be reversible to allow the making of a dental prosthesis using a direct or in inverted injection and improve the fit of the prosthesis on the model.

Another object of the present invention is to provide a molding machine and method which reduces strains on the dentures by improving the spruing of the plastic into the mold.

SUMMARY OF THE INVENTION

The foregoing and other objects of the present invention are achieved by providing an apparatus for preparing injection molded prosthesis comprising:

a cartridge containing resin to form a prosthesis, the cartridge having an upper surface with an opening and a lower surface;

a plunger contacting the lower surface;

a flask containing a mold to form the prosthesis, the flask having an opening for alignment with the opening in the cartridge;

heating means disposed adjacent the cartridge to heat the resin prior to injecting the resin into the flask; and

means applying pressure to the lower surface of the cartridge so that heated resin is ejected from the cartridge through the opening in the cartridge and the opening in the flask to permit the resin to enter the flask and form the prosthesis.

In one form of the invention, the apparatus comprises a compression plate which is located between the cartridge and the flask; the plate has a lower surface having a shape corresponding to that of the upper surface of the cartridge and an upper face having an opening for alignment with the opening of the cartridge and the opening of the flask.

In another preferred form of the invention, the opening of the cartridge and the opening of the plate are conical in shape.

In another form of the invention the heating means consist of a pair of heating elements, one being disposed in the plunger and the other being disposed circumferentially to the cartridge.

The present invention also relates to a method for producing injection molded prosthesiss which comprises the steps of:

inserting a resin-containing cartridge into a molding apparatus;

applying heat to the cartridge to heat the resin;

applying pressure to the cartridge so that the cartridge, injection molding apparatus and a flask containing a mold to form the prosthesis align with one another.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. It should be understood, however, that this detailed description, while indicating preferred embodiments of the invention, is given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an elevational view of the apparatus of the present invention;

Figure 2 is a cross-sectional elevation of the upper part of the apparatus;

Figure 3 is a cross-sectional view of a flask; and

Figure 4 is a cross-sectional view of another embodiment of a cartridge used with the apparatus of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to figure 1, there is shown an apparatus, generally designated 10, for preparing injection molded prosthesis. It comprises a housing 12 in which is mounted a DC motor 14 that drives a belt 16 mounted to a pair of pulleys 18 and 20. Pulley 20, through a speed reducing element 22, serves to actuate a ball bearing screw jack 24.

Referring to figure 2, to the top end 25 of the jack is secured an adaptor 27 to which is mounted a piston or plunger 26 having a cover 28.

A tubular casing 30 surrounds the adaptor and the piston and has its upper peripheral side wall threadedly engaged to a head 32. Casing 30 is fixed to a base 31 of the housing 12.

Shown on the top face of the plunger cover 28 is a cartridge 34 disposed at the center of the injection apparatus. The cartridge is a substantially flat cylinder, containing resin 35 or other suitable

thermoplastic or thermoset material, and has a conical opening 36 in its upper surface 38. However, opening 36 may be closed prior to being used in the apparatus of the present invention.

A compression plate 40 is supported onto the cylindrical inner side wall of the casing 30 over the cartridge 34. The upper face of the plate has an annular inverted V-shaped ridge 41 while its lower surface 42 has a central portion 44 corresponding in shape to the upper surface 38 of the cartridge. It also includes a conical opening 46 in which is received the conical portion 36 of the cartridge.

Resting on the upper face of the compression plate 40 is a flask shown schematically in figure 2 as consisting of two halves 48 and 50. The lower face of the bottom flask half 50 has an annular inverted V-shaped recess to correspondingly receive the annular ridge 41 of the plate thereby ensuring proper alignment of the flask onto the compression plate. A flat cover 52 surmounts the upper flask half 48.

The compression plate comprises a pair of handles 51 and 53 which will allow the plate with its flask placed thereon to be lowered into position in the chamber of casing 30 over the piston cover 28.

In the center of casing 30, there is provided a radial ring 54 within which is received a circumferential heating element 56 and over which extends a covering ring 58. A heat insulating element 60 separates the casing 30 from the heating ring 54 as well as from the heated lower chamber 62 in which is housed the heat plunger 26. An insulating sleeve 63 surrounds chamber 62.

The plunger 26 and its cover 28 are further heated by means of an element 64 controlled by a thermocouple 66. An insulation element 68 extends between the screw jack adaptor 27 and cover 28 of the piston 26.

Figure 3 shows a cross-section of the flask halves 48 and 50, both filled with plaster 70 and defining centrally a cavity 72 conforming to a dental prosthesis to be made and including an opening 74 and a channel 76 for receiving injected thermoplastic resin.

In operation, a cartridge 34 is positioned on the piston cover 28 and confined within the tubular heating ring 54. The resin in the cartridge is heated by elements 56, 64. The compression plate 40 with a flask positioned on its top face is then lowered into the chamber and is suspended over the cartridge with its peripheral edge resting on a shoulder on the interior wall of the chamber. The lowering of the compression

plate is accomplished by using handles 51 and 53. Cover 32 is screwed on tightly thus closing the chamber. When motor 14 is activated, the screw jack 24 causes the piston to be raised causing the cartridge to come into contact with the lower face of the compression plate with opening 36 fitting into the conical opening 46.

As the plunger applies upward pressure through its cover 28 onto the cartridge 34 bearing against plate 40, the plastic resin is ejected from opening 36 into opening 74 of the flask. As the plunger continues to apply pressure, the cartridge is deformed as the flat bottom face 39 of the cartridge is pushed inwardly; the volume of the cartridge decreases. The cartridge is made from steel; however, other pliable, but pressure resistant, material, such as an alloy of aluminum and steel can also be used.

The two parts of the flask are automatically clamped together without the use of clamping devices due to the tight securement of the casing head 32 against which bears the flask cover 52.

The entire device is an automatic self-aligning device requiring no guiding elements due to the fact that the cartridge opening fits into the opening in the bottom of the compression plate and that the flask opening 74 is properly located over the openings 36 and 46 following

the engagement of the annular ridge 41 in the annular groove 49.

The entire device is either single stand alone or desk top unit which is controlled through a keyboard (not shown). Once the device is activated, the heating and plunger movement steps are all automatically performed by the station, thus eliminating any further user input. The speed and amount of pressure are all controlled and automated by the device which may be manual of computer controlled.

Figure 4 illustrates another embodiment of a cartridge which may be used with the present invention. The cartridge 134 in which is included a thermoplastic resin 135 is formed of an upper face 138 having an opening 136 and a lower face 139 which is recessed with respect to the cylindrical side wall of the cartridge. This recess is shaped to correspondly receive the piston cover of the plunger. It is also formed of pliable and pressure resistant material so that this surface 139 will progressively be pushed inwardly towards the top surface 138.

This embodiment of the invention also eliminates any possibility of deformation or shrinkage. Since the cartridge fits into a recess in the bottom of the compression plate, and since the bottom of the

cartridge fits on the top of the plunger and in the center of the peripheral heating element, the entire device is an automatic self-aligning device which requires no guiding elements. The pressure from the plunger deforms the bottom plate portion of the cartridge, forcing the material out of the opening at the center of the top portion. As the plunger applies more and more pressure, the volume of the cartridge shrinks as the bottom diaphragm of the cartridge is deformed.

A key advantage to the present apparatus is the elimination of additional clamping devices to avoid resin leakage from the cartridge. Compressive tightening force is applied automatically at the interface of the components (the cartridge, heat chamber, plate and flask) by the ascending force of the plunger, which applies a uni-axial force on the cartridge which, in turn, transmits this same force to the upper plate, which in turn transfers it to the flask, which transfers the force to the head, thereby completing the auto-clamping process. The only element which is fixed during the whole process is the head 32. The flat shape of the cartridge makes the process possible. Since the cartridge has an active surface larger than that of the flask cavity, it is possible to obtain contact forces on the flask greater than the hydrostatic force generated by the injection. Consequently, the force of the process (hydrostatic force of the plastic) inside the cavity is

less than the clamping force of the flask, avoiding any resin leakage.

Since the cartridge is sized so that it contains more thermoplastic resin than is required to fill the mold cavity contained by the flask, the pressure in the cavity is maintained while the resin solidifies. This back pressure permits good dimensional stability by significantly decreasing any possibility of deformation or shrinkage, and thereby greatly decreases the possibility that the resin will be flowing out of the flask and resulting in a less than optimum prosthesis.

The heating elements heat the cartridge at approximately 400° centrigrade. The insulation and covers are selected so that uniform temperature distribution is achieved and plastic degradation is prevented. A precision of +/- 5°C on the cartridge envelope is necessary to assure reproducible injections.

The flask is designed reversible to accept a direct or an inverted denture model. Inverted injection is used for upper prosthesis whereas direct injection is used for lower denture. In an inverted injection, the channel delivering the plastic melt is located at the rear of the palatal region denture and directed on the edge of the impression side. Inverted injection gives a better fit of the denture with respect to the original

model by providing a mechanical anchoring and by reducing the thermal shrinkage of the resin during cooling.

Although the invention has been described above with respect to specific forms, it will be evident to a person skilled in the art that it may be modified and refined in various ways. It is therefore wished to have it understood that the present invention should not be limited in scope, except by the terms of the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus for preparing injection molded prosthesis comprising:

a cartridge containing resin to form a prosthesis, said cartridge having an upper surface with an opening and a lower surface;

a plunger contacting said lower surface;

a flask containing a mold to form said prosthesis, said flask having an opening for alignment with said opening in said cartridge;

heating means disposed adjacent said cartridge to heat said resin prior to injecting said resin into said flask; and

means applying pressure to said lower surface of said cartridge so that heated resin is ejected from said cartridge through said opening in said cartridge and said opening in said flask to permit said resin to enter said flask and form said prosthesis.

2. An apparatus as defined in claim 1, further comprising a compression plate disposed between said cartridge and said flask; said plate having a lower surface corresponding in shape to that of the upper surface of said cartridge and an upper face having an

opening for alignment with said opening of said cartridge and said opening of said flask.

3. An apparatus as defined in claim 1, wherein said heating means consist of a pair of heating elements, one disposed in said plunger and another heating element disposed circumferentially to said cartridge.

4. An apparatus as defined in claim 3, further comprising insulating elements surrounding said heating elements.

5. An apparatus as defined in claim 1, wherein said cartridge is cylindrically shaped; said lower surface of said cartridge being flat and acting as a diaphragm.

6. An apparatus as defined in claim 5, wherein said plunger has a top circular face having dimensions slightly less than that of said flat lower surface of said cartridge whereby, as said diaphragm is being deformed by said plunger, said plunger penetrates within the cylindrical side walls of said cartridge.

7. An apparatus as defined in claim 1, wherein said cartridge is cylindrically shaped; said

lower surface of said cartridge has a recess having a dimension corresponding to that of said plunger.

8. An apparatus as defined in claim 1 wherein said cartridge, said plunger, said flask and said heating means are received within a casing having a cover secured thereon; said cover clamping said flask upon the application of a force of said plunger by said pressure applying means.

9. An apparatus as defined in claim 8, wherein said force exerted on said flask is greater than force generated by the resin being injected into said flask, thus preventing leakage.

10. An apparatus as defined in claim 1, wherein said pressure applying means consist of a screw jack actionned by a DC motor.

11. An apparatus as defined in claim 2, wherein said opening in said cartridge is conical and wherein said lower face of said plate has a conically shaped central recess.

12. A method for producing injection molded prosthesis comprising the steps of:

inserting a resin-containing cartridge into a molding apparatus;

applying heat to said cartridge to heat said resin;

applying pressure to said cartridge so that said cartridge, injection molding apparatus and a flask containing a mold to form said prosthesis align with one another.

13. A method as recited in claim 12, comprising the further step of:

applying additional pressure by said plunger to a diaphragm in said cartridge so that said resin is ejected from said cartridge into said mold to form said prosthesis.

14. A method as recited in claim 12, further comprising the step of choosing the size of said cartridge so that said cartridge will contain more resin than required to fill said mold.

15. A method as recited in claim 13, wherein force exerted on said flask is greater than force generated by said resin being injected into said mold to prevent any leakage of resin.

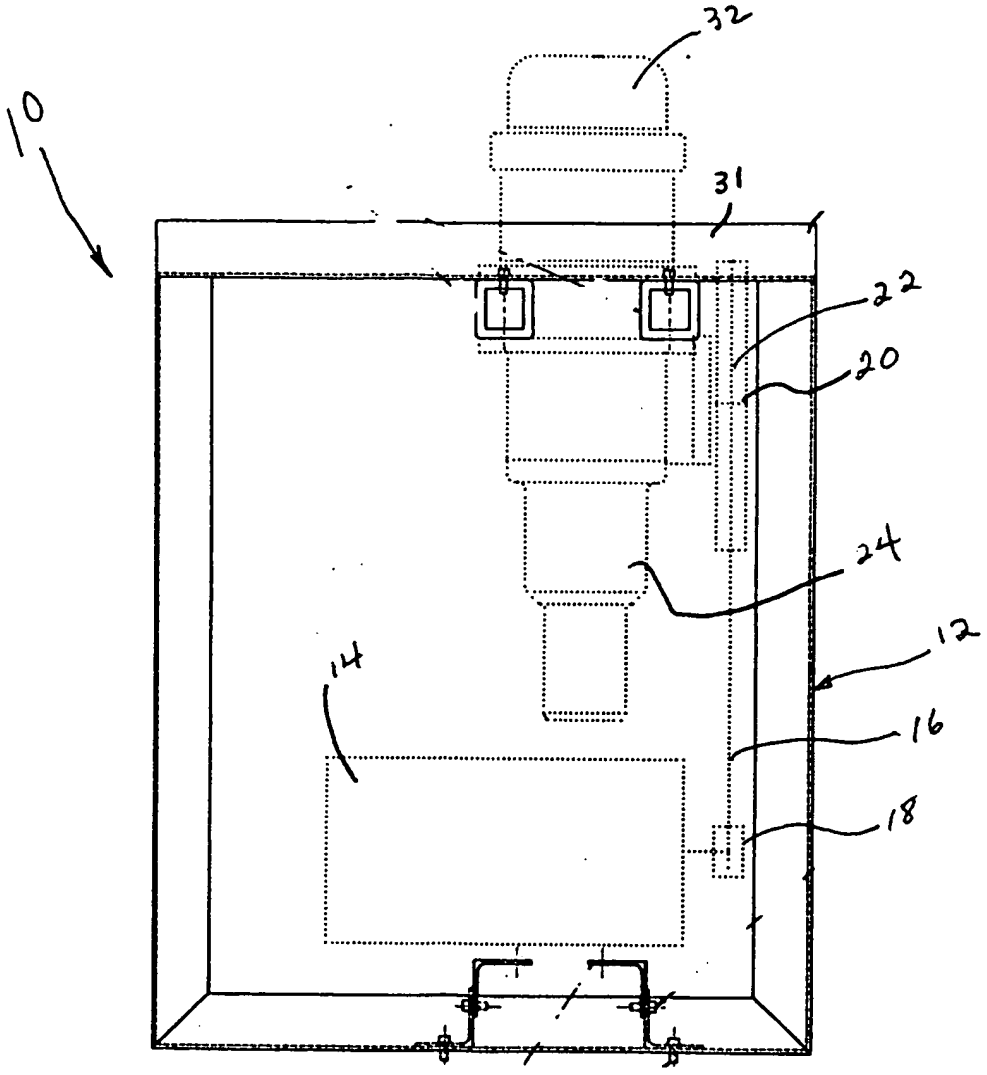

Fig. 1

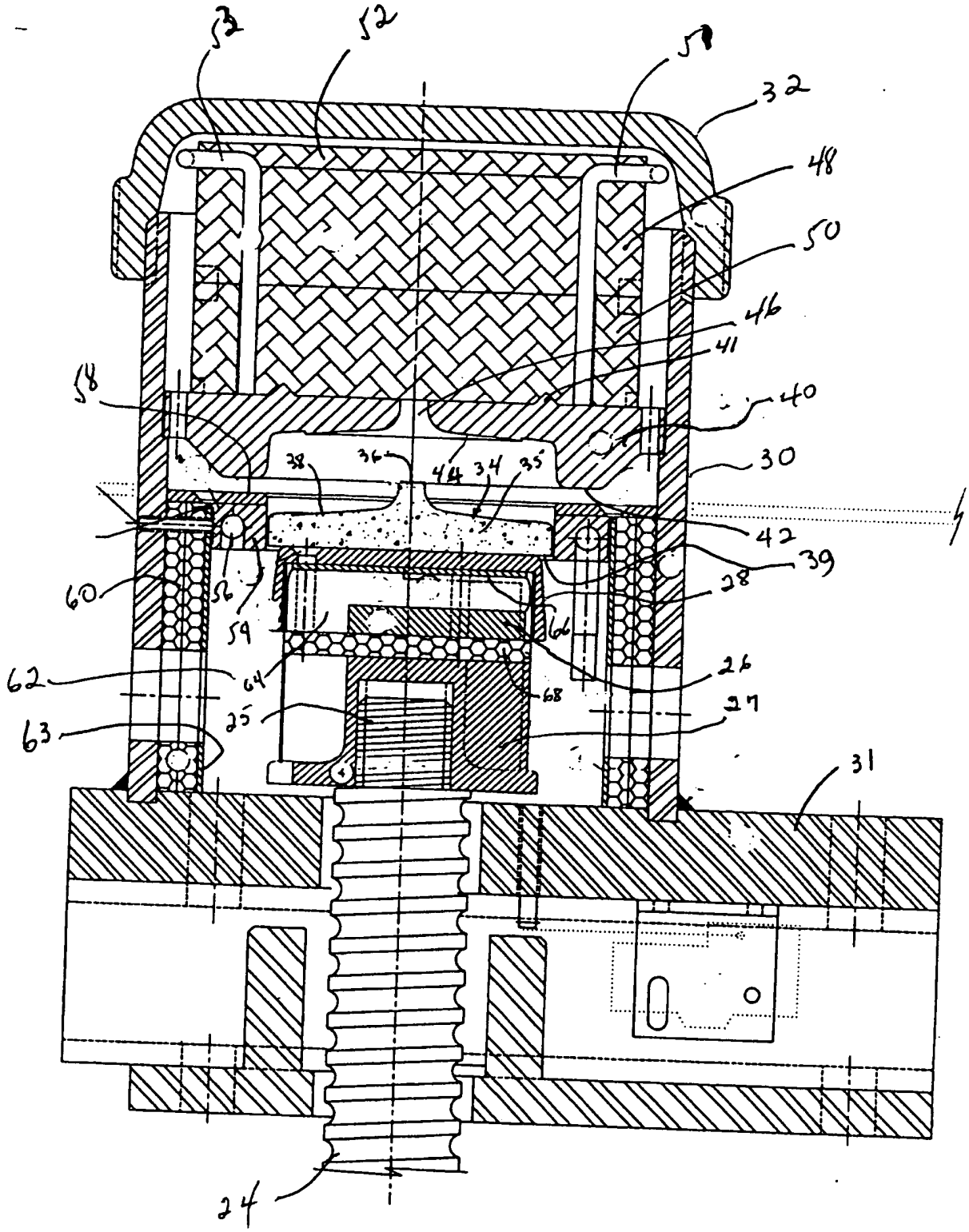
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Fig. 2

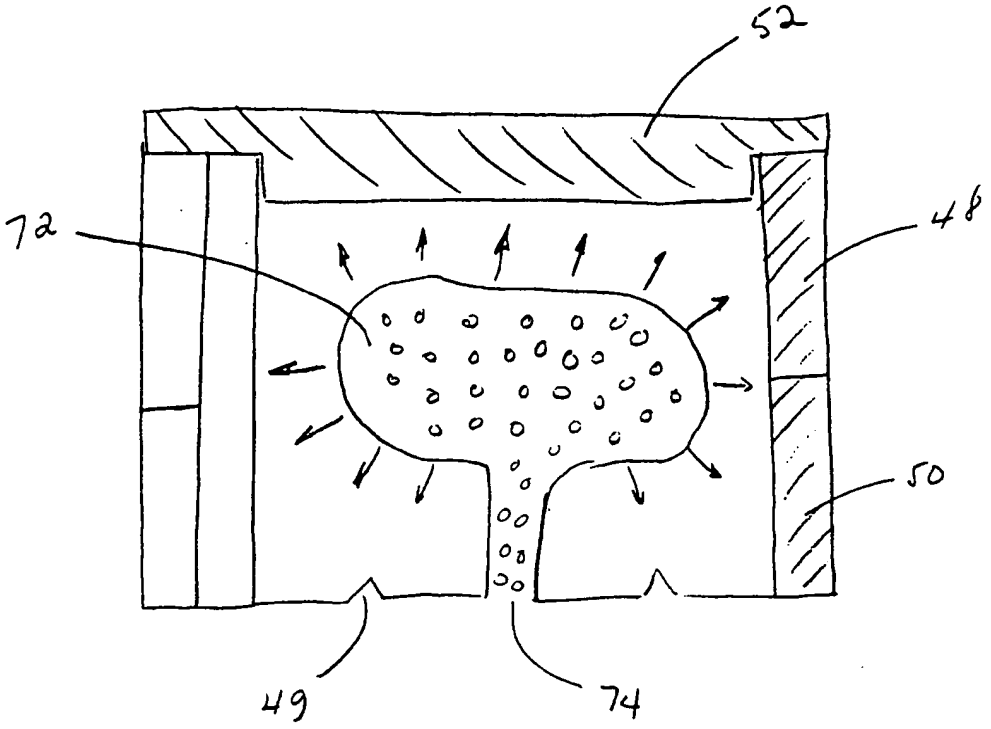

Fig 3

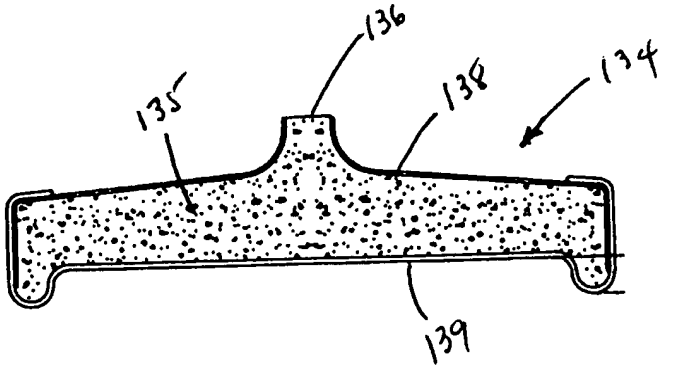

Fig. 4